RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: 4th

Wisconsin Department of Transportation
DT1241 2009

Research, Development and Technology Transfer		
Program: (Choose One) ☐ **Policy Research** ☐ **Pooled Fund** **TPF #** ☒ **Wisconsin Highway Research Program** ☐ **Other**		
Project Title: Evaluation of the Foundation Movements of Transportation Structures		
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WisDOT Technical Contact/Phone #: Robert Arndorfer / (608)246-7940	**Other Project ID:**	
Project Investigator/Phone # (agency & contact): James Schneider jamess@cae.wisc.edu) 608-890-2662	**Approved Starting Date:**	2/5/2009
WisDOT Comments:	**Original End Date:**	2/5/2012
	Current End Date:	2/5/2012
Sponsor: Wisconsin Department of Transportation	**Number of Extensions:**	

Schedule Status:

☐ On schedule ☐ Ahead of schedule
☒ On revised schedule ☐ Behind schedule (Please explain below)

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
$109,893.00	$3,488.87	$17,708.14	16	10

Project Description:
The overall research objective of this study is to produce a document summarizing simplified design procedures for evaluation of foundation movements for transportation structures within the LRFD framework. Recommendations for the measurement and selection of input parameters for those design procedures will also be provided.

Progress This Quarter: (Includes project committee meetings, work plan status, contract status, significant progress, etc.)
The project consists of five main tasks (1) Literature Review and Database Development; (2) Field Monitoring of Shallow Foundations; (3) Field Monitoring of Deep Foundations; (4) Field Monitoring of Laterally Loaded Piles; and (5) Data Compilation and Analysis. Tasks this quarter have focused on Literature Review and Database Development as well as development and calibration of instrumentation that will be applied in stages 2, 3, and 4.

1. Literature Review and Database Development

This quarter has focused on analysis of shallow foundations in sands. Four subset databases were used:

- Normally Consolidated (NC) Sands with CPT average q_c values (26 tests)
- Overconsolidated (OC) Sands with CPT average q_c values (52 tests)
- Normally Consolidated (NC) Sands with average SPT N values (33 tests)
- Overconsolidated (OC) Sands with average SPT N values (88 tests)

For preliminary analysis for the database, elastic theory was used:

$$s/B = f(q/E_{eq},I)$$

Therefore if the ratio of settlement to footing width is plotted against the ratio of footing stress to equivalent modulus, trends should arise. In this case we are estimating E_{eq} from CPT q_c which, on average, can be related to SPT N-value using a factor of 4.5 (i.e., $q_c=4.5N_{60}$). Therefore if we plot s/B against the ratio of footing stress to q_c or 4.5N, we should get the ratio of E/q_c divided by an influence factor (I), that is approximately equal to 0.8.

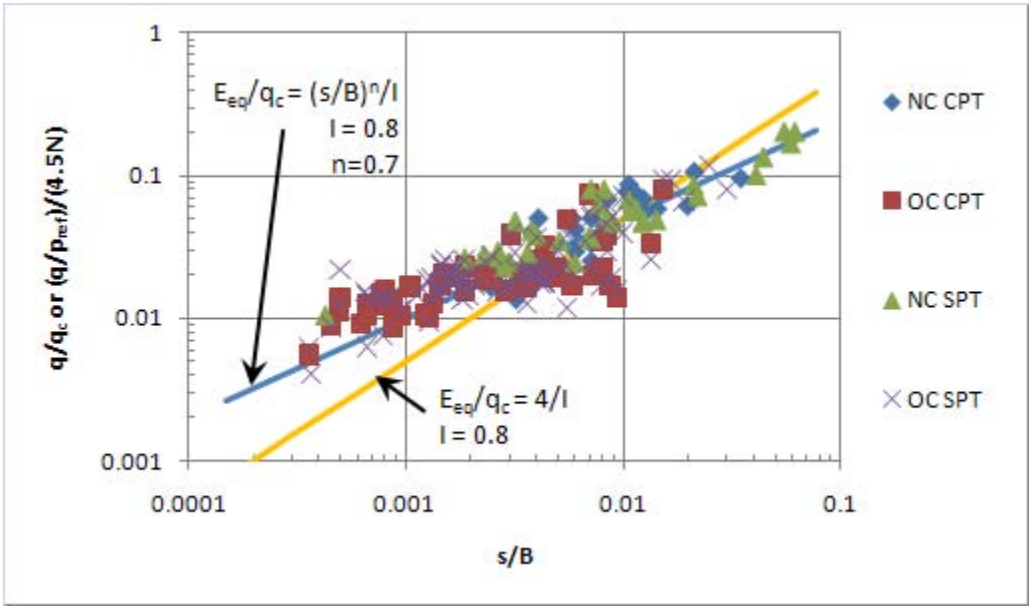


Figure 1. Comparison of penetration resistance to shallow foundation settlement on sands

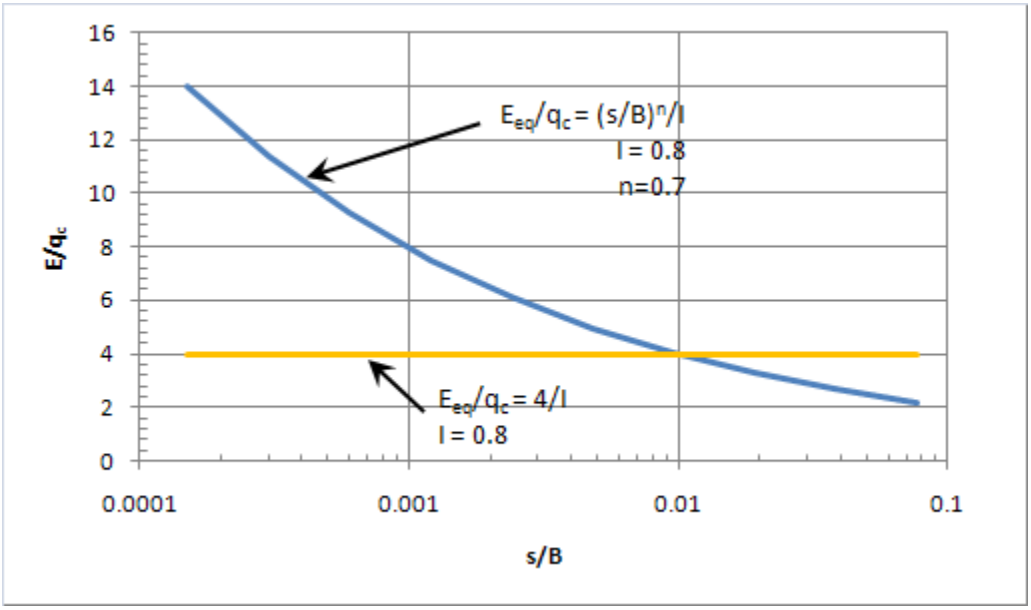


Figure 2. Soil stiffness nonlinearity for evaluation of settlement of shallow foundations on sands

Figure 1 plots data of $q_{footing}/q_c$ or $q_{footing}/4.5N$ (an indication of stiffness) against s/B (an indication of strain). Trend lines are shown with E/q_c equal to 4, a typical correlation for natural sands and $E/q_c = (s/B)^n$. Where n is an exponent that increases the curve fit. An exponent of 0.7 fits the data best, as discussed previously by Burland & Burbidge (1986). In Figure 2, we explore what the use of estimation of E/q_c as a function of $(s/B)^{0.7}$ physically relates to, namely, soil stiffness is nonlinear and decreases with increasing shear strain. Typical correlations assuming E/qc equal 4 will overpredict settlements for small s/B, and underpredict settlements at large s/B. In this case the two trends produce equivalent answers for s/B of 1% of the foundation width, or that corresponding to typical design conditions.

2. Instrumentation Development

Activities this quarter involved purchasing field measurement equipment and developing procedures to calibrate wireless deformation sensors in a controlled laboratory environment. Sensors and the testing arrangement are shown in Figures 3 and 4. Use of these sensors should minimize impact to construction schedule and minimize damage to monitoring equipment (no wires). The devices need to be calibrated in the lab and weatherized for year round monitoring.

Figure 3a. Wireless deformation measurement sensors and circuit boards for attaching strain gauges

Figure 3b. Field computer for data collection

Figure 4a. Laboratory test setup with wireless accelerometers for deformation measurement

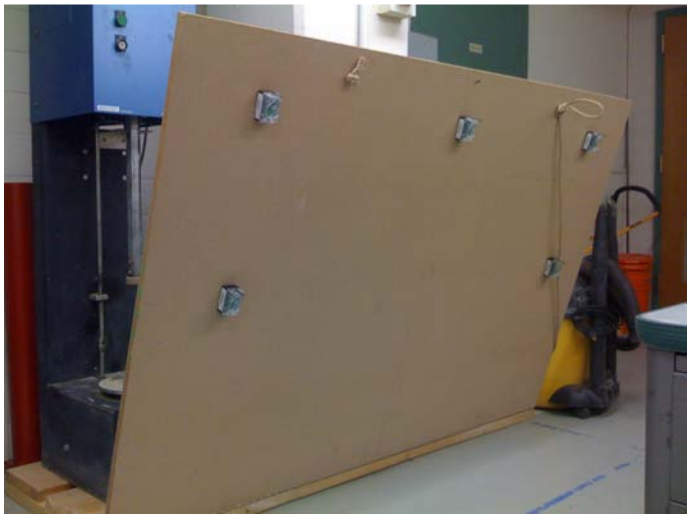
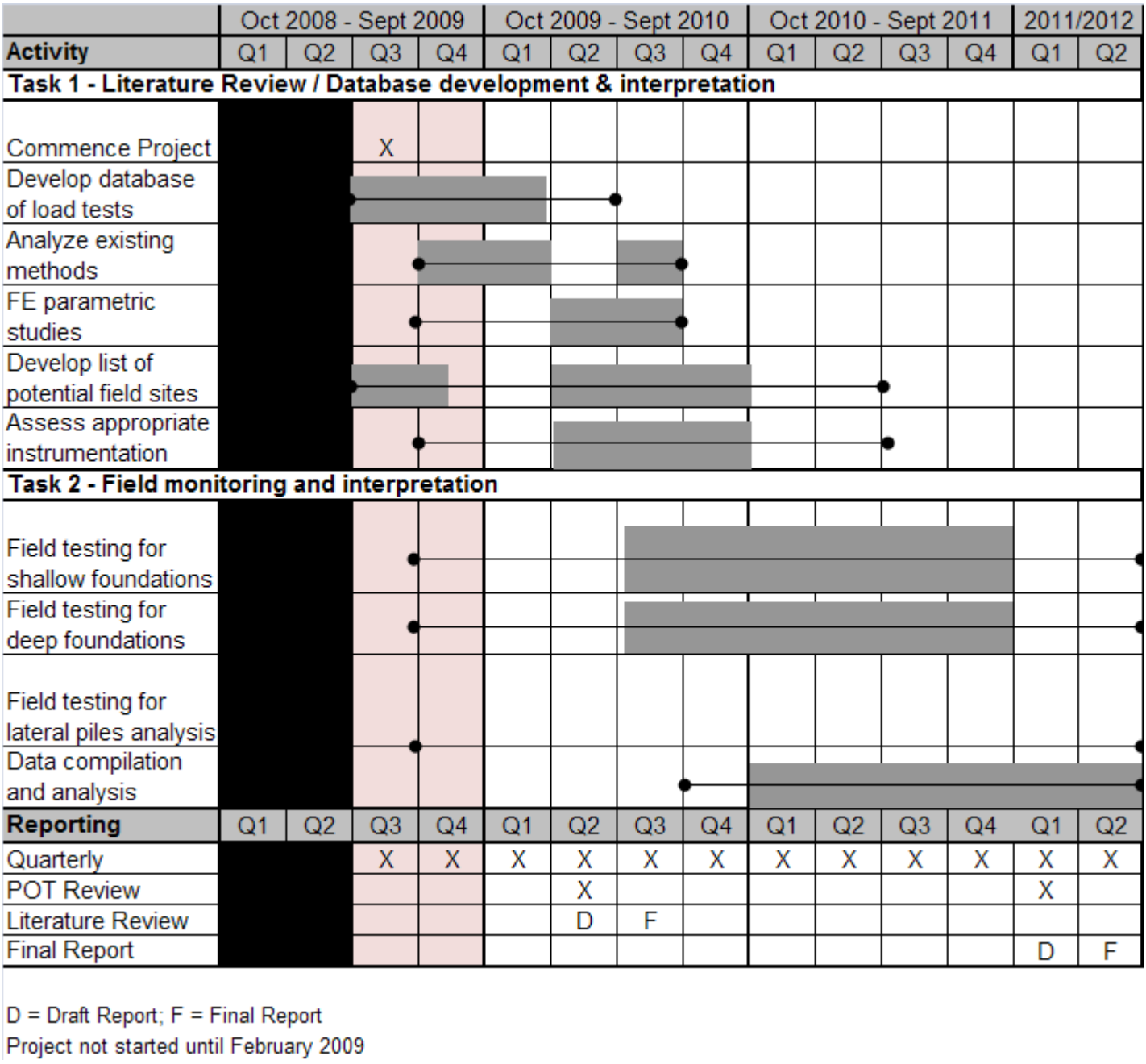


Figure 4b. Test wall rotated at a know displacement

Anticipated Work Next Quarter:
The main tasks for next quarter are to complete laboratory calibration of the deformation instrumentation, and add load measurement capabilities. It is planned to winterize and install the equipment at an outdoor test site to examine and address potential problems that may arise over monitoring next year. Continued work on the database of foundation load tests and assessment of existing methods is explored.

Circumstances Affecting Progress and/or Budget:
It does not look like any field test sites will be instrumented within the first year, but winterization of equipment will be verified to minimize potential issues for next year. A list of potential field sites has not yet been generated, although, that task is scheduled for completion early next year.

Gantt Chart:



D = Draft Report; F = Final Report

Project not started until February 2009